NORTH Dakota | Environmental Quality
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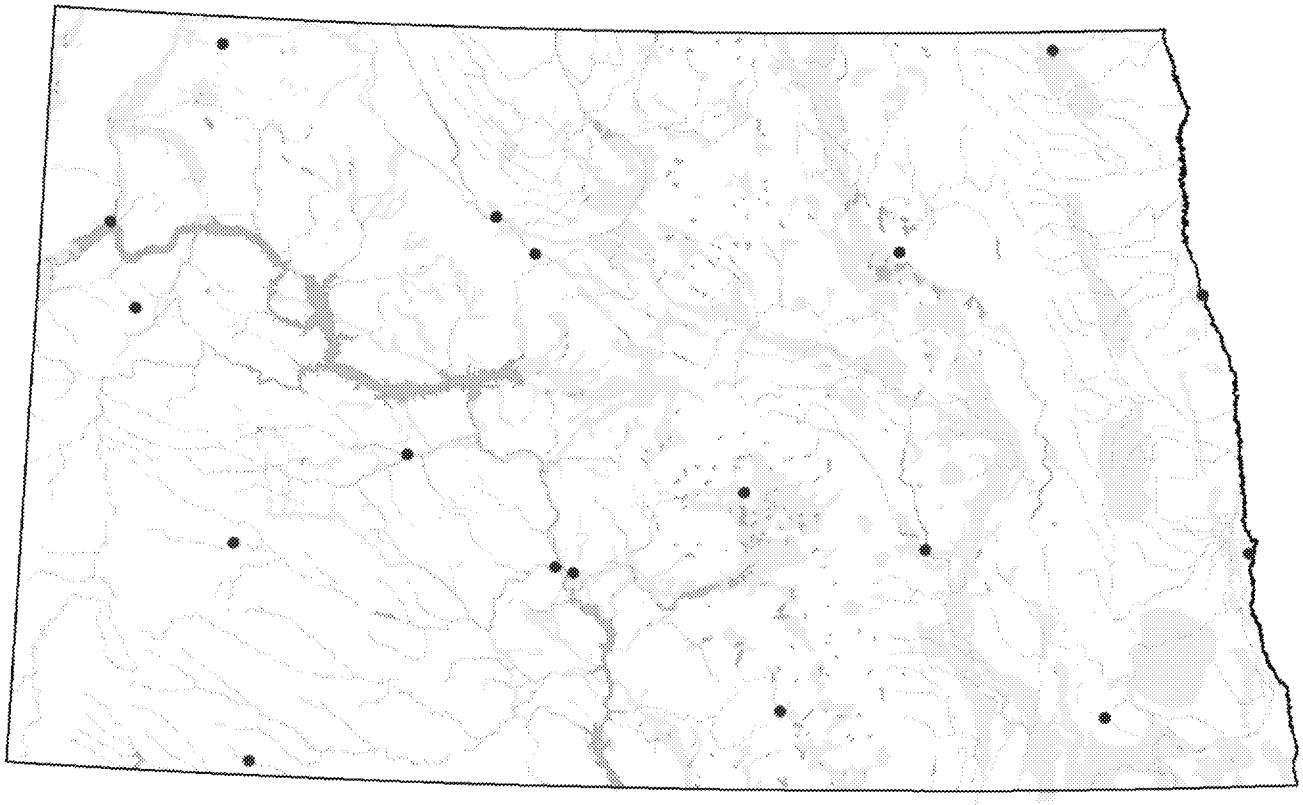
North Dakota Department of Environmental Quality

North Dakota Statewide 2018 Per- and Polyfluoroalkyl Substances (PFAS) Presence/Absence Survey



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10:2 Fluorotelomersulfonate	10:2 F
Aqueous Film Forming Foam	AFFF
Environmental Health Section	EHS
Eurofins Lancaster Laboratories Environmental, LLC	Eurofins
Fire Training Area	FTA
Health Advisory Level	HAL
Interstate Technology Regulatory Council	ITRC
Nanograms per liter	ng/l
North Dakota Department of Health	NDDoH
North Dakota Department of Environmental Quality	NDDEQ
Parts Per Trillion	ppt
Per -and Polyfluoroalkyl Substances	PFAS
Perfluorobutanoic acid	PFBA
Perfluorobutanesulfonic acid	PFBS
Perfluorodecanesulfonate	PFDS
Perfluorodecanoic acid	PFDA
Perfluorododecanoic acid	PFDoA
Perfluoroheptanesulfonate	PFHpS
Perfluoroheptanoic acid	PFHpA
Perfluorononanesulfonate	PFNS
Perfluorooctanesulfonamide	PFOS
Perfluoropentanesulfonate	PFPeA
Perfluoropentanoic acid	PFPeS
Perfluorotetradecanoic acid	PFTeDA
Perfluoroundecanoic acid	PFUnA
Perfluorohexanesulfonic acid	PFHxS
Perfluoroheptanoic acid	PFHpA
Perfluorononanoic acid	PFNA
Perfluorooctanoic acid	PFOA
Perfluorooctane sulfonate	PFOS
Quality Assurance/Quality Control	QA/QC
Reverse Osmosis	RO
Reverse Osmosis Purified Laboratory Water	RO-Purified DW
Third Unregulated Contaminated Monitoring Rule	UCMR3
U.S Environmental Protection Agency	EPA

Executive Summary

On April 6, 2018, the Environmental Health Section of the North Dakota Department of Health (NDDoH)[1]created a work group tasked with conducting an initial baseline survey to determine the presence/absence of Per- and Polyfluoroalkyl Substances (PFAS) in North Dakota. Samples were taken from a variety of sites where PFAS would potentially be present such as landfills, drinking water treatment plants, wastewater treatment plants, and fire training areas.

LANDFILL LEACHATE SAMPLES

Leachate samples were collected from 17 landfills. The laboratory analytical results show detections in every landfill. This is expected as landfills accept a variety of waste from many sources, including municipalities and industrial facilities.

Exceedances of the U.S. Environmental Protection Agency's (EPA) health advisory limit (HAL) of 70 parts per trillion (ppt) for Perfluorooctanoic Acid (PFOA) + Perfluorooctanesulfonic Acid (PFOS) were found in 15 of the leachate samples. Landfills 2, 10, and 13 showed a greater variety of PFAS contamination than the other landfills. These three landfills accept larger volumes of wastes.

DRINKING WATER TREATMENT PLANT SAMPLES

A total of 14 samples were collected from seven drinking water treatment plants. One source water sample and one treated water sample were collected from each location.

Of the drinking water treatment plants sampled, five plants were found to have detections below the EPA's PFOA + PFOS HAL: four with detections in both the source and treated water samples and one with a detection in the treated water sample. Detections in drinking water treatment plants were low — low enough that they may be explained by something as simple as a gasket or glue containing Teflon or another PFAS chemical commonly used in piping or plant construction.

[1] The Environmental Health Section of the North Dakota Department of Health became the North Dakota Department of Environmental Quality on April 29, 2019.

WASTEWATER TREATMENT PLANT SAMPLES

Wastewater samples were collected from 11 different wastewater treatment plants. While all samples had detections for PFAS analytes, none exceeded the EPA's PFOA + PFOS HAL. The accumulation of these substances in wastewater treatment plants is due to the household use of PFAS-containing substances or from the acceptance of landfill leachate.

GROUNDWATER SAMPLES

Fire Training Areas

Five groundwater samples were collected from four fire training areas. Samples taken at two of the sites, FTA 4 and FTA 5, showed detections of PFOA + PFOS with FTA 4 having concentrations exceeding EPA's HAL.

Landfill Groundwater Monitoring Wells

A total of 17 monitoring wells were sampled at 11 of the landfills sampled for leachate. Only nine of the monitoring wells showed detections of PFAS analytes and even then, at low levels. No exceedances for the EPA's HAL were found, indicating that the landfill liners are intact or the contamination has not yet reached groundwater.

MISCELLANEOUS SAMPLES

Miscellaneous samples were collected from the department's chemistry laboratory's reverse osmosis (RO) purified water filter and from an oilfield-related spill. The RO-purified water contained several detections of PFAS analytes, including PFOA, indicating that the chemistry laboratory's system has components made of Teflon or another PFAS-containing material. The oilfield-related spill contained a single, low-level detection of PFBA.

FIELD AND EQUIPMENT BLANK SAMPLES

Eleven blanks (three equipment and eight field samples) were collected to ensure quality control. Laboratory analytical results show no detections, demonstrating that there were no field or equipment cross-contamination issues occurring during the collection and transporting processes.

1.0 Introduction

Per- and Polyfluoroalkyl Substances (PFAS) are a group of chemicals that have been manufactured and used in a variety of industries in the United States since the 1940s. These chemicals have shown to be persistent in the environment and the human body, and there is evidence to suggest that their presence can have adverse effects on human health.

On April 6, 2018, the Environmental Health Section of the NDDoH created a work group tasked with conducting an initial baseline survey to determine the presence and/or absence of PFAS in North Dakota.

1.1 Background

PFAS are a large, complex group of man-made fluorinated organic compounds that were discovered in 1938 and have been mass produced since 1947 (Prevedouros et al., 2006; Griffith, 2017). More than 6,000 PFAS compounds are known to exist, although not all are in current use or production. PFAS are made when the hydrogen ions on a carbon chain are either completely or partially replaced with fluorine ions, resulting in a carbon-fluorine bond that makes these compounds resistant to most degradation processes including microorganisms, direct light, atmospheric photooxidation, and hydrolysis (Haley Aldrich, 2018).

PFAS compounds have become essential in many industries due to their useful and unique properties. They are chemically stable, reduce surface tension to a much lower state than other surfactants, repel water and oil, possess friction-reducing properties, and function in environments where other products would degrade (3M, 1999). These properties have given rise to a variety of industrial and commercial products that are resistant to oil, grease, water, soil, and stains. The PFAS compounds are used in effective firefighting foams, metal plating and coating formulations, polyurethane production, inks, varnishes, and lubricants (3M, 1999; Prevedouros et al., 2006). Additionally, they are considered vital in the aviation, mining and gas, photographic imaging, semiconductor, automotive, construction, and electronics industries (ITRC, 2017).

2.0 Study

The Environmental Health Section assembled a work group with the purpose of determining whether or not PFAS are present in North Dakota, particularly in the groundwater. Research conducted by federal, state, and private entities has shown that

PFAS contamination would likely be found in landfills, drinking water treatment plants, wastewater treatment plants, industrial areas, military bases, and firefighting training areas.

Many commercial and industrial products that either contain PFAS or are the result of PFAS production often end up in landfills. As the products break down, the compounds will slowly work their way through the soil until they are dissolved in water and transported to a leachate pond or into the underlying groundwater. At landfills, groundwater was sampled using monitoring wells that were located on site.

Wastewater treatment plants tend to contain high levels of PFAS compounds that are the result of discharges from landfills, firefighting activities, and manufacturing/ industrial facilities. Current treatment methods are inefficient in removing PFAS and, in some cases, can result in changes to the types and concentrations found in the effluent (Schultz et al., 2006; Hamid and Li, 2016). Nearly half of the sludge produced by wastewater treatment plants is applied as a biosolid to agricultural land. If the effluent is contaminated, the biosolid will potentially be contaminated as well. Research has shown that land treated with PFAS-contaminated biosolids for an extended time period can result in elevated concentrations in the adjacent groundwater and surface water (ITRC, 2017).

Aqueous film forming foam (AFFF) is a PFAS-based foam developed in the 1960s and used by both military and civilian firefighting departments to extinguish fires at military bases, airports, refineries, and firefighting training facilities. While AFFF is slowly being replaced with alternative foams, many entities still have it on hand for emergency use and training purposes.

Within the oil and gas industry, AFFF systems are required at petroleum refineries and bulk storage facilities by the National Fire Protection Association. However, best management practices for their use and evaluations for the use of alternative PFAS-free foams have been put into practice since 2001 (Antea Group, 2018; ITRC, 2017).

PFAS has been identified as an issue in the adjacent and underlying groundwater of military bases due to fire training exercises and the storage and release of associated chemicals.

Between 2013-2015, 13 public water systems in North Dakota were sampled for six of the most commonly detected PFAS compounds: PFOS, PFOA, perfluorobutanesulfonic

acid (PFBS), perfluorohexanesulfonic acid (PFHxS), perfluoroheptanoic acid (PFHpA), and perfluorononanoic acid (PFNA) under the EPA's Third Unregulated Contaminant Monitoring Rule (UCMR3). Although results from the UCMR3 samples indicated non-detects, the work group decided that additional sampling should be done since the methods for detection and quantitation for these compounds have improved.

2.1 Site Selection

Landfills were chosen by the Division of Waste Management based on the type of landfill, the waste accepted, and the age. Leachate samples were collected from either the ponds or the pipes. Monitoring wells were chosen by the Division of Water Quality based on the information provided by the Division of Waste Management on well location and groundwater gradient. At least one well sampled was downgradient.

Fire training areas were chosen based on whether a permanent or a general training location could be identified and the availability of monitoring wells in or around the area. Monitoring wells were located and chosen by the Division of Water Quality.

Wastewater treatment plants were chosen by the Division of Water Quality. The sampled facilities were those that either served a larger population (greater than 20,000) or where the treatment ponds had not been discharged in at least five years, allowing for the accumulation of contaminants.

A groundwater sample was taken at the site of a brine spill from a monitoring well that is known to have impacts from the spill.

Drinking water treatment systems were chosen by the Division of Municipal Facilities based on either the population served or if there was an industrial site nearby. Systems chosen used either groundwater or surface water sources.

Military bases with histories of using AFFF are located near Grand Forks, Fargo, Minot, and Bismarck. These bases were not sampled based on conversations with relevant base personnel indicating that they are performing their own Phase II PFAS studies and will allow the department access to their findings once the reports have been finalized.

Table 1 lists the sample's identification, location where the sample was taken, and type of sample that was collected.

2.2 Sample Procedures

Because of the prevalence of PFAS chemicals in most everyday items and the low detection rates used by laboratories, sampling protocols for PFAS are stringent.

The equipment used for sampling is verified to be made from PFAS-free materials and disposable to lessen the chance of cross-contamination between sampling sites. Sample bottles and coolers were provided by the department's chemistry laboratory. Samplers wore field clothes that did not contain any Tyvek, Gore-Tex, or similar material. Nitrile gloves were worn when sampling, and only equipment provided to field personnel was used.

Monitoring wells were sampled using disposable bailers and 100% cotton twine. The well volume method was used, and water quality meters were used to collect pH, specific conductivity, and temperature measurements in between purges.

Samples from landfills were either taken from leachate ponds or leachate pipes. If taken from ponds, a disposable bailer and 100% cotton twine were used to collect samples. If taken from a leachate pipe, a Peristaltic pump and disposable peristaltic pump tubing were used.

Samples from wastewater treatment plants were taken from either discharge ponds or discharge pipes. If the sample was taken from a discharge pond, a sample bottle was lowered into the pond and filled. If taken from a discharge pipe, the sampling point was identified.

Two samples were collected at each drinking water plant — one from the raw, source water and the second from the treated water.

Sampling and standard operating procedures can be found in the *North Dakota Department of Health Environmental Health Section North Dakota Statewide Per- And Polyfluoroalkyl Substances (PFAS) Field Sampling Plan* (NDDoH, 2018A).

Table 1. PFAS sample identification, location where the sample was taken, and type of sample collected

Sample ID	Associated Location	Sample Type	Sample ID	Associated Location	Sample Type
Landfill 1A	Active Landfill	Landfill Leachate	WWTP 3	Wastewater Treatment Plant	Wastewater
Landfill 1B	Active Landfill	Landfill Leachate	WWTP 4	Wastewater Treatment Plant	Wastewater
Landfill 1C	Active Landfill	Landfill Leachate	WWTP 5	Wastewater Treatment Plant	Wastewater
Landfill 1D	Active Landfill	Landfill Leachate	WWTP 6	Wastewater Treatment Plant	Wastewater
Landfill 1E	Active Landfill	Landfill Leachate	WWTP 7	Wastewater Treatment Plant	Wastewater
Landfill 2	Active Landfill	Landfill Leachate	WWTP 8	Wastewater Treatment Plant	Wastewater
Landfill 3	Active Landfill	Landfill Leachate	WWTP 9	Wastewater Treatment Plant	Wastewater
Landfill 4	Active Landfill	Landfill Leachate	WWTP 10	Wastewater Treatment Plant	Wastewater
Landfill 5	Active Landfill	Landfill Leachate	WWTP 11	Wastewater Treatment Plant	Wastewater
Landfill 6	Active Landfill	Landfill Leachate	Landfill 3 MW 1	Active Landfill	Groundwater
Landfill 7	Active Landfill	Landfill Leachate	Landfill 3 MW 2	Active Landfill	Groundwater
Landfill 8	Active Landfill	Landfill Leachate	Landfill 4 MW 1	Active Landfill	Groundwater
Landfill 9	Active Landfill	Landfill Leachate	Landfill 5 MW 1	Active Landfill	Groundwater
Landfill 10	Active Landfill	Landfill Leachate	Landfill 5 MW 2	Active Landfill	Groundwater
Landfill 11	Active Landfill	Landfill Leachate	Landfill 6 MW 1	Active Landfill	Groundwater
Landfill 12A	Inactive Landfill	Landfill Leachate	Landfill 7 MW 1	Active Landfill	Groundwater
Landfill 12B	Inactive Landfill	Landfill Leachate	Landfill 8 MW 1	Active Landfill	Groundwater
Landfill 13	Active Landfill	Landfill Leachate	Landfill 8 MW 2	Active Landfill	Groundwater
DW 1S	Drinking Water Treatment Plant	Source	Landfill 10 MW 1	Active Landfill	Groundwater
DW 1T	Drinking Water Treatment Plant	Treated	Landill 10 MW 2	Active Landfill	Groundwater
DW 2S	Drinking Water Treatment Plant	Source	Landfill 12A MW 1	Inactive Landfill	Groundwater
DW 2T	Drinking Water Treatment Plant	Treated	Landfill 14 MW 1	Inactive Landfill	Groundwater
DW 3S	Drinking Water Treatment Plant	Source	Landfill 15 MW 1	Inactive Landfill	Groundwater
DW 3T	Drinking Water Treatment Plant	Treated	Landfill 15 MW 2	Inactive Landfill	Groundwater
DW 4S	Drinking Water Treatment Plant	Source	Landfill 16 MW 1	Active Landfill	Groundwater
DW 4T	Drinking Water Treatment Plant	Treated	Landfill 16 MW 2	Active Landfill	Groundwater
DW 5S	Drinking Water Treatment Plant	Source	FTA 1	Fire Training Area	Groundwater
DW 5T	Drinking Water Treatment Plant	Treated	FTA 2	Fire Training Area	Groundwater
DW 6S	Drinking Water Treatment Plant	Source	FTA 3	Fire Training Area	Groundwater
DW 6T	Drinking Water Treatment Plant	Treated	FTA 4	Fire Training Area	Groundwater
DW 7S	Drinking Water Treatment Plant	Source	FTA 5	Fire Training Area	Groundwater
DW 7T	Drinking Water Treatment Plant	Treated	GW1	Brine Spill	Groundwater
WWTP 1	Wastewater Treatment Plant	Wastewater	RO-Purified DW	Laboratory	RO Purified Water
WWTP 2	Wastewater Treatment Plant	Wastewater			

2.3 Sample Analysis

Eurofins Lancaster Laboratories Environmental, LLC (Eurofins) was selected over several other laboratories via the state procurement process to perform the PFAS analysis. PFAS samples are analyzed in ppt using a LC-MS/MS. A list of the 32 analytes tested for are found in Appendix A.

3.0 Quality Assurance/Quality Control

Quality assurance/quality control (QA/QC) procedures were established to ensure that project objectives were met for those who would use the data. The main purpose of a QA/QC plan is to maintain a high level of quality for field activities to ensure that the collected data is representative of current conditions. The QA/QC plan details procedures for field equipment calibration, data collection, record retention, sample collection, handling, custody, and the collection of duplicate and blank samples. These procedures were implemented to minimize the chance of cross-contamination and/or background contamination, and to ensure sample validity by documenting sample custody from the time of collection until it reaches the laboratory. Detailed procedures can be found in the *Quality Assurance Project Plan for the North Dakota Statewide Per-And Polyfluoroalkyl Substances (PFAS) Assessment* (NDDoH, 2018B).

4.0 Results

A total of 88 samples, including primary, duplicate, and blank samples, were collected and analyzed from 47 sample sites which include 13 landfills, 12 groundwater sites, 10 wastewater treatment plants, seven drinking water treatment plants, four fire training areas, and one miscellaneous RO-purified, laboratory grade water sample from the department's chemistry laboratory. Table 2 lists the total number of primary, duplicate, and blank samples collected. Table 3 breaks down the total number of samples (including primary, duplicate, and blank samples) taken at each type of sample site.

The collected samples were submitted to Eurofins to be analyzed. Table 4 lists the PFAS analytes that were sampled for and, if available, their abbreviations.

Overall, laboratory analytical results indicate that out of the 32 analytes, 23 were detected in 53 of 67 primary samples. The five most commonly detected analytes in the samples were PFOA, PFOS, PFBA, PFHpA, and PFHxA. Table 5 lists the analytes in the samples from most to least detected.

Chart 1 is a visual representation of the 32 analytes tested for and the sites where they were detected.

Table 2. Samples by type

Sample Type	# of Samples
Primary	67
Duplicate	10
Field Blank	8
Equipment Blank	3

Table 3. Samples by site

Site Type	# of Samples
Landfill	26
Groundwater Monitoring Well	26
Drinking Water Treatment Plant	15
Wastewater Treatment Plant	15
Fire Training Area	5
Misc. Sample	1

Table 4. PFAS analytical names and abbreviations

Name	Abbreviation
10:2 fluorotelomersulfonate	10:2 F
4:2 fluorotelomersulfonate	4:2 F
6:2 fluorotelomersulfonate	6:2 F
8:2 fluorotelomersulfonate	8:2 F
NEtFOSAA	--
NEtPFOSA	--
NEtPFOSAE	--
NMeFOSAA	--
NMePFOSA	--
NMePFOSAE	--
Perfluoro-octanesulfonate	PFOS
Perfluorobutanesulfonate	PFBS
Perfluorobutanoic acid	PFBA

Perfluorodecanesulfonate	PFDS
Perfluorodecanoic acid	PFDA
Perfluorododecanesulfonate	PFDoS
Perfluorododecanoic acid	PFDoA
Perfluoroheptanesulfonate	PFHpS
Perfluoroheptanoic acid	PFHpA
Perfluorohexadecanoic acid	--
Perfluorohexanesulfonate	PFHxS
Perfluorohexanoic acid	PFHxA
Perfluorononanesulfonate	PFNS
Perfluorononanoic acid	PFNA
Perfluorooctadecanoic acid	--
Perfluorooctanesulfonamide	PFOSA (FOSA)
Perfluorooctanoic acid	PFOA
Perfluoropentanesulfonate	PFPeA
Perfluoropentanoic acid	PFPeS
Perfluorotetradecanoic acid	PFTA
Perfluorotridecanoic acid	PFTeDA
Perfluoroundecanoic acid	PFUnA

Note: -- No abbreviation available

Table 5. PFAS analytes detected in samples

Detected Analyte	
1 PFOA	**13** NEtFOSAA
2 PFOS	**14** PFOSA
3 PFBA	**15** NMeFOSAA
4 PFHpA	**16** 4:2 F
5 PFHxA	**17** 8:2 F
6 PFHxS	**18** PFUnA
7 PFBS	**19** NMePFOSAE
8 PFPeA	**20** PFHpS
9 PFNA	**21** NEtPFOSAE
10 6:2 F	**22** PFDS
11 PFPeS	**23** PFDoA
12 PFDA	

Chart 1. The 32 PFAS analytes tested for and where they were detected

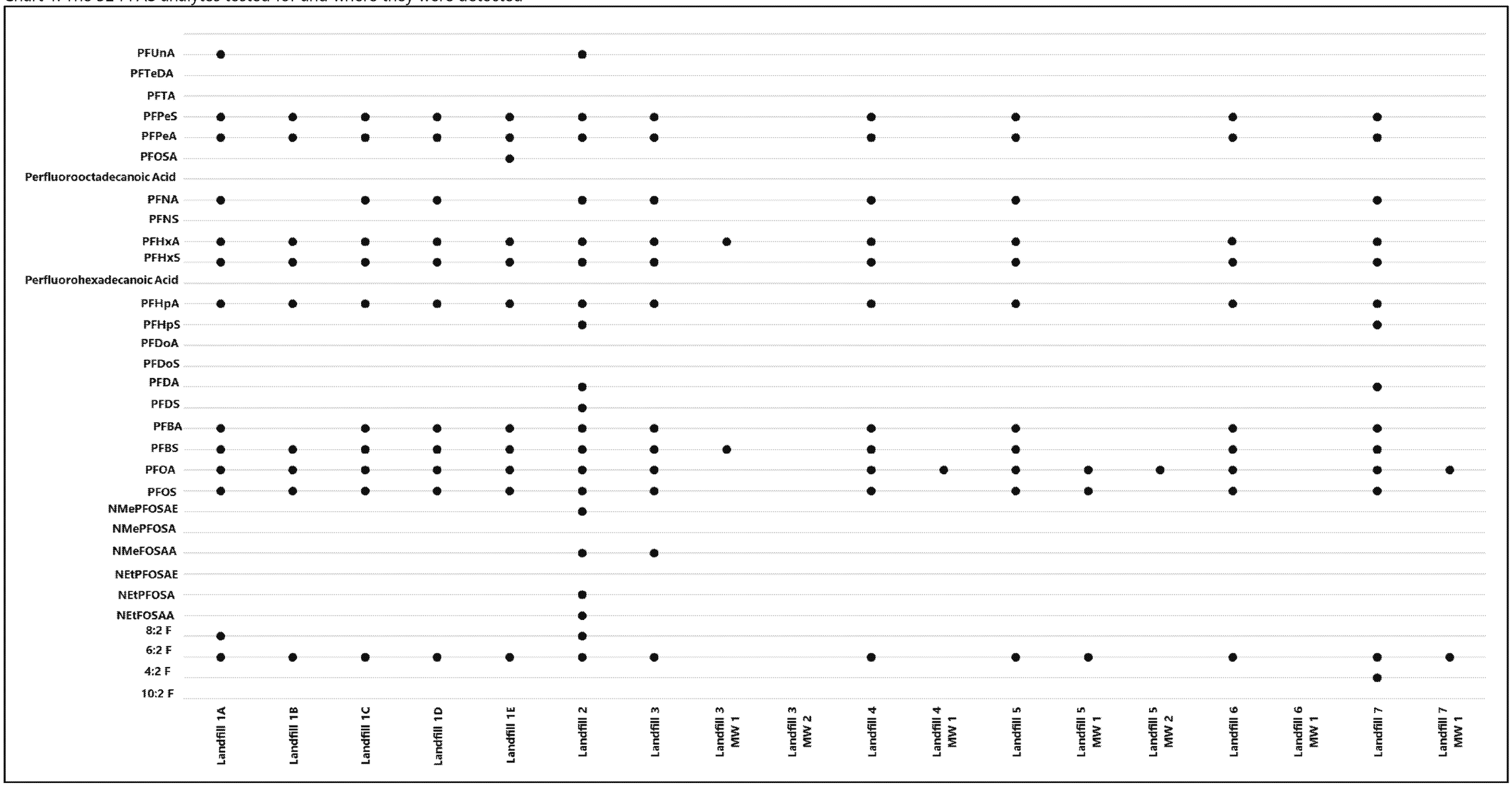


Chart 1. (cont'd). The 32 PFAS analytes tested for and where they were detected

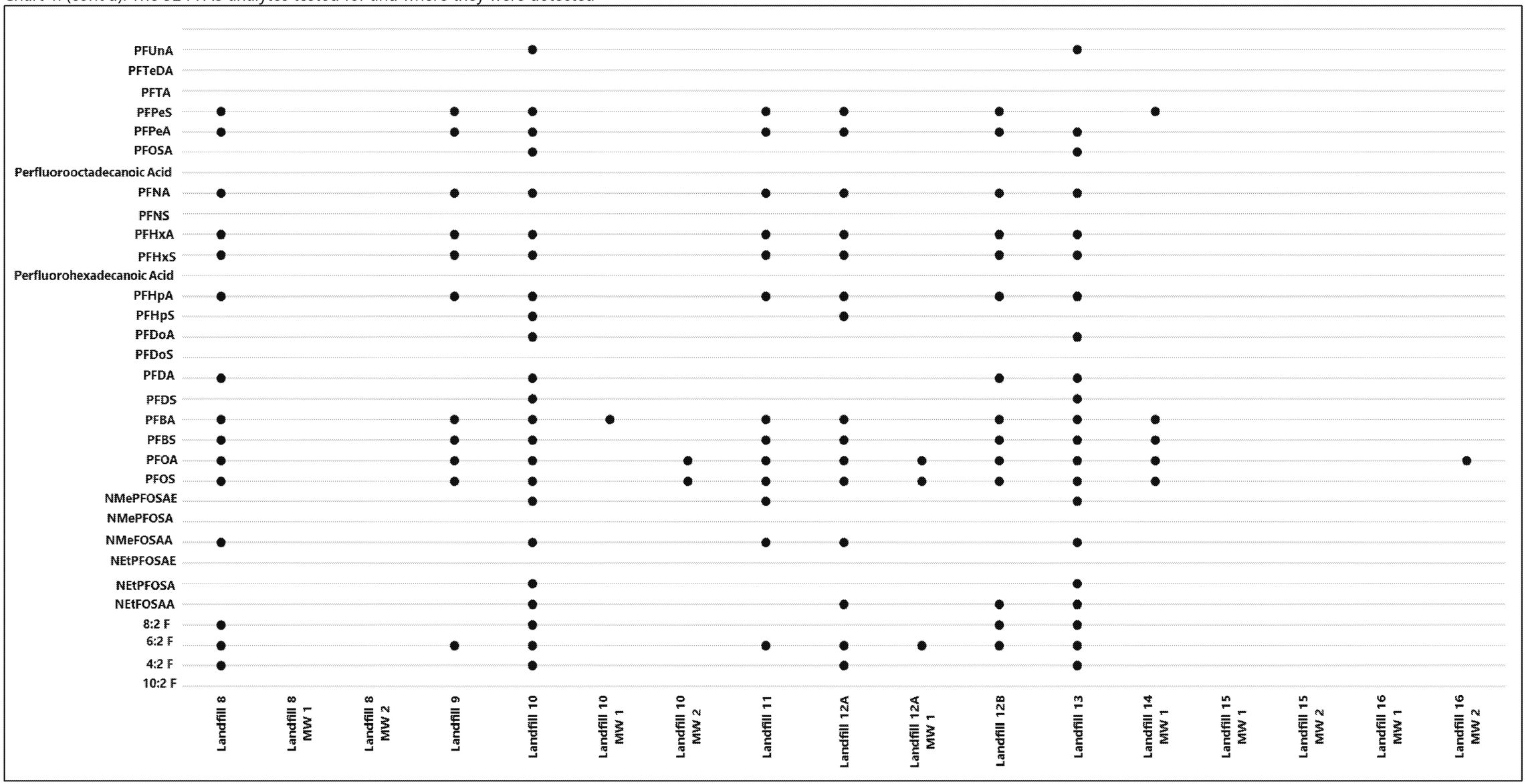
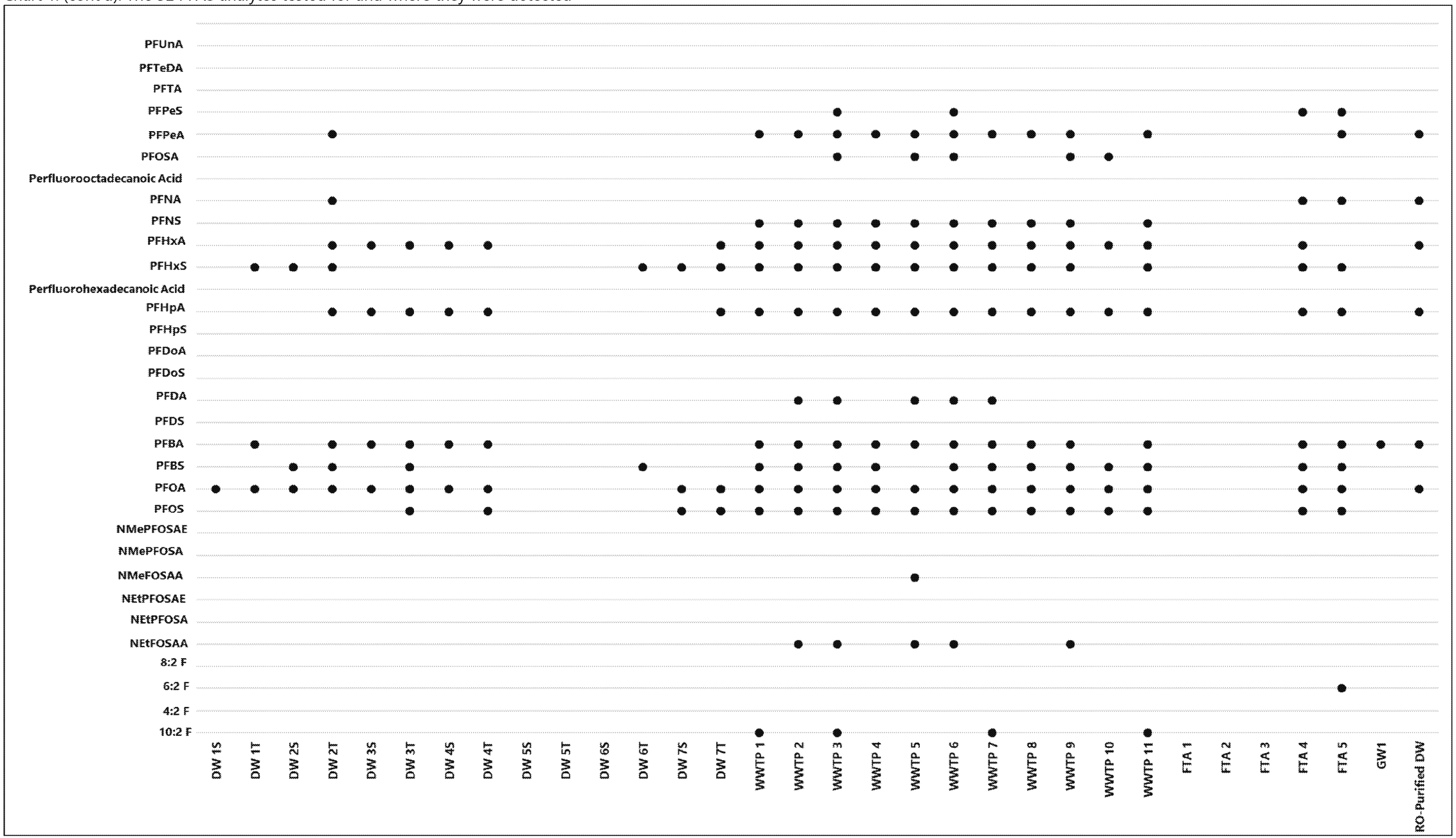


Chart 1. (cont'd). The 32 PFAS analytes tested for and where they were detected



4.1 Landfills

Eighteen primary leachate samples were taken from 13 landfills across the state. All of the samples analyzed contained at least one PFAS analyte. The most commonly detected analytes were as follows: 6:2 F, PFOS, PFOA, PFBS, PFHpA, PFHxS, PFHxA, and PFPeA. These five analytes were detected in all 18 primary samples.

In 2018, the EPA set a HAL for PFOS and PFOA at either 70 ppt each or PFOS + PFOA at 70 ppt. No other PFAS analytes currently have an established federal or North Dakota HAL or maximum contaminant levels. Exceedances of this HAL were found in 15 of the landfill's leachate samples.

Chart 2 shows the number of landfill leachate samples with detected PFAS analytes. Analytical detections and exceedances are in Table 6. Complete laboratory results are found in Appendix B.

Chart 2. The number of landfill leachate samples with PFAS detections

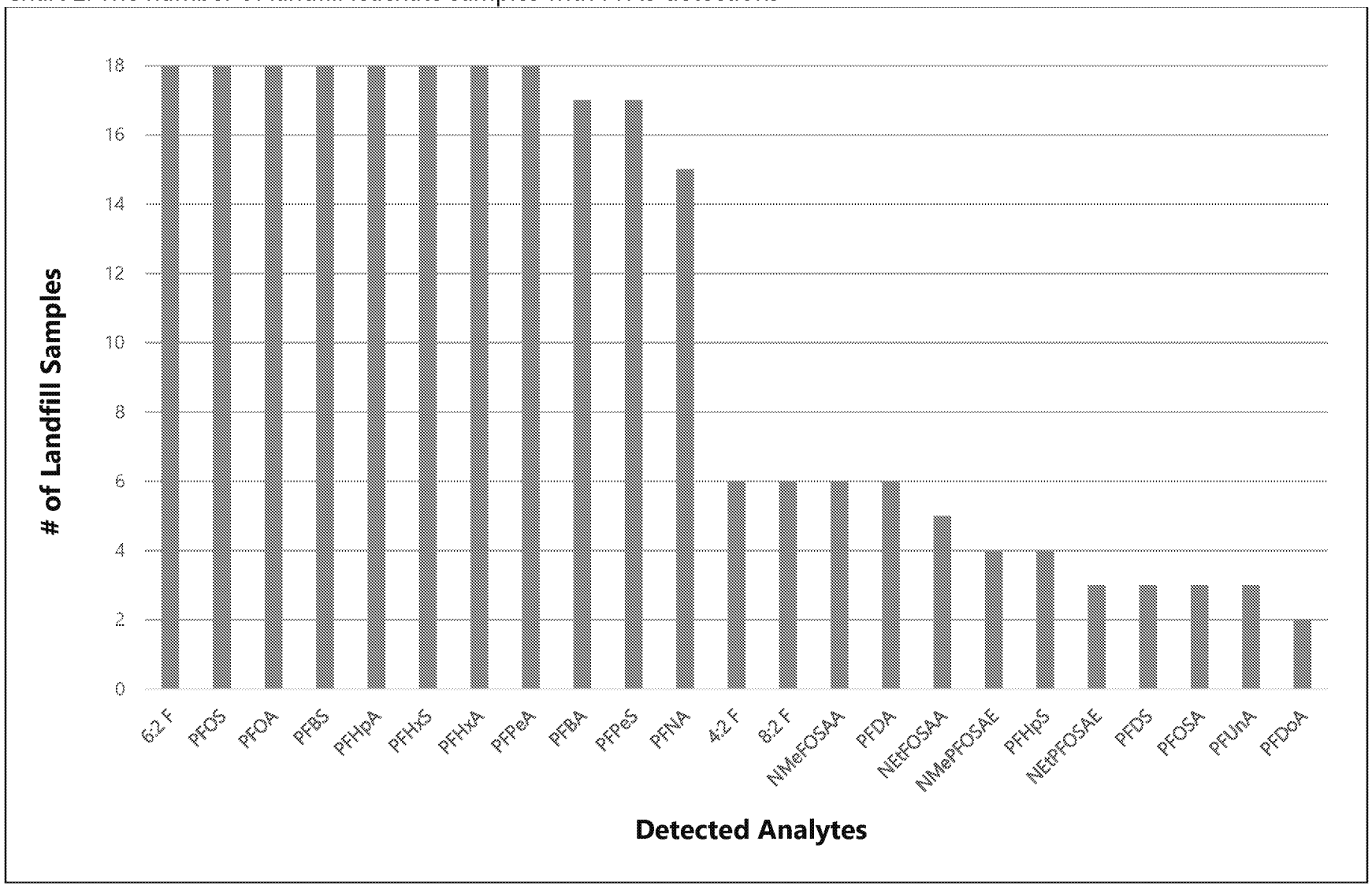


Table 6. Landfill leachate samples with PFAS analytical detections and exceedances

Site Identification			Landfill 1A	Landfill 1B	Landfill 1C	Landfill 1D	Landfill 1E	Landfill 2	Landfill 3	Landfill 4	Landfill 5	Landfill 6	Landfill 7	Landfill 8	Landfill 9	Landfill 10	Landfill 11	Landfill 12A	Landfill 12B	Landfill 13
Analyte	Health Advisory Levels	Unit	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results
4:2 F	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	**12 J**	N.D.	N.D.	N.D.	N.D.	**7.0 J**	**8.5 J**	N.D.	**8.2 J**	N.D.	**2.5 J**	N.D.	**11 J**
6:2 F	Not Established	ppt	**6,800**	**3,100**	**580**	**160**	**12**	**290**	**62**	**38**	**67**	**9.4 J**	**120**	**100**	**68**	**140**	**64**	**26**	**22**	**320**
8:2 F	Not Established	ppt	**170 J**	N.D.	N.D.	N.D.	N.D.	**40**	N.D.	N.D.	N.D.	N.D.	N.D.	**12 J**	N.D.	**18 J**	N.D.	N.D.	**32**	**14 J**
NEtFOSAA	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	**250**	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	**64**	N.D.	**3.5 J**	**14 J**	**20**
NEtPFOSAE	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	**23**	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	**110**	N.D.	N.D.	N.D.	**12 J**
NMeFOSAA	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	**130**	**6.0 J**	N.D.	N.D.	N.D.	N.D.	**14 J**	N.D.	**170**	**6.2 J**	N.D.	N.D.	**130**
NMePFOSAE	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	**40**	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	**240**	**5.9 J**	N.D.	N.D.	**84**
PFOS	70	ppt	**42 J**	**95 J**	**7.4 B**	**23 B**	**2.3 JB**	**310 B**	**45 B**	**15**	**19**	**5.6 J**	**77**	**40**	**43**	**190**	**25**	**56**	**48**	**180**
PFOA		ppt	**160**	**150**	**78**	**10**	**4**	**1,700**	**250**	**140**	**260**	**52**	**580**	**720**	**340**	**1,200**	**220**	**310**	**720**	**1,000**
PFBS	Not Established	ppt	**240**	**160**	**82**	**30**	**20**	**230**	**87**	**41**	**54**	**25**	**66**	**150**	**55**	**640**	**91**	**39**	**13**	**450**
PFBA	Not Established	ppt	**350**	N.D.	**460**	**200**	**140**	**510**	**520**	**280**	**340**	**220**	**610**	**1,000**	**510**	**960**	**560**	**240**	**230**	**710**
PFDS	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	**3.1 J**	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	**8.2 J**	N.D.	N.D.	N.D.	**5.3 J**
PFDA	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	**20**	N.D.	N.D.	N.D.	N.D.	**5.7 J**	**6.7 J**	N.D.	**35**	N.D.	N.D.	**10**	**41**
PFDoA	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	**12**	N.D.	N.D.	N.D.	**5.7 J**
PFHpS	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	**4.9 J**	N.D.	N.D.	N.D.	N.D.	**2.8 J**	N.D.	N.D.	**4.3 J**	N.D.	**1.8 J**	N.D.	N.D.
PFHpA	Not Established	ppt	**270**	**190**	**140**	**37**	**27**	**620**	**160**	**74**	**150**	**29**	**300**	**520**	**190**	**430**	**170**	**120**	**180**	**490**
PFHxS	Not Established	ppt	**160**	**140**	**34**	**28**	**9.5**	**1,200**	**140**	**59**	**100**	**29**	**340**	**330**	**300**	**650**	**160**	**130**	**130**	**430**
PFHxA	Not Established	ppt	**1,900**	**1,400**	**760**	**170**	**130**	**2,000**	**670**	**530**	**650**	**220**	**1,200**	**3,600**	**760**	**1,900**	**810**	**400**	**1,500**	**2,100**
PFNA	Not Established	ppt	**25 J**	N.D.	**3.8 J**	**5.7**	N.D.	**55**	**20**	**5.7 J**	**11**	N.D.	**22**	**22**	**25**	**58**	**6.3 J**	**1.8 J**	**22**	**100**
PFOSA	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	**5.3 J**	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	**7.4 J**	N.D.	N.D.	N.D.	**2.6 J**
PFPeS	Not Established	ppt	**50 J**	**33 J**	**7.1**	**6.6**	**1.8 J**	**28**	**8.2 J**	**5.8 J**	**6.3 J**	**13**	**20**	**26**	**13**	**28**	**20**	**13**	**5.3 J**	N.D.
PFPeA	Not Established	ppt	**1,200**	**810**	**560**	**190**	**130**	**660**	**420**	**310**	**340**	**74**	**710**	**1,600**	**460**	**570**	**520**	**210**	**350**	**910**
PFUnA	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	**2.7 J**	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	**7.9 J**	N.D.	N.D.	N.D.	**6.5 J**

Notes:
N.D. - Non Detect
J - Indicates an Estimated Value
Bold - Analytical Detection
[ ] - Analytical Exceedance

4.2 Groundwater Monitoring Wells

Twenty-three primary groundwater samples were collected from monitoring wells: 17 associated with landfills, five with fire training areas, and one with an oilfield-related brine spill that was known to have impacts to the adjacent groundwater.

PFAS analytes were detected in 12 of the samples: nine associated with landfills, two with fire training areas, and one with the brine-related spill. PFOA and PFOS were the most detected, found in 10 and six samples, respectively, then followed by PFBA, PFBS, 6:2 F, PFHpA, PFHxS, PFHxA, PFNA, PFPeS, and PFPeA.

Fire Training Areas 4 and 5 were the only wells to show exceedances of the EPA's PFOS + PFOA 70 ppt HAL. All other PFOS and PFOA detections were found to be well below the HAL.

Chart 3 presents the number of monitoring wells with detected analytes. Analytical detections and exceedances are in Table 7. Complete analytical laboratory results can be found in Appendix B.

Chart 3. The number of groundwater samples with PFAS detections

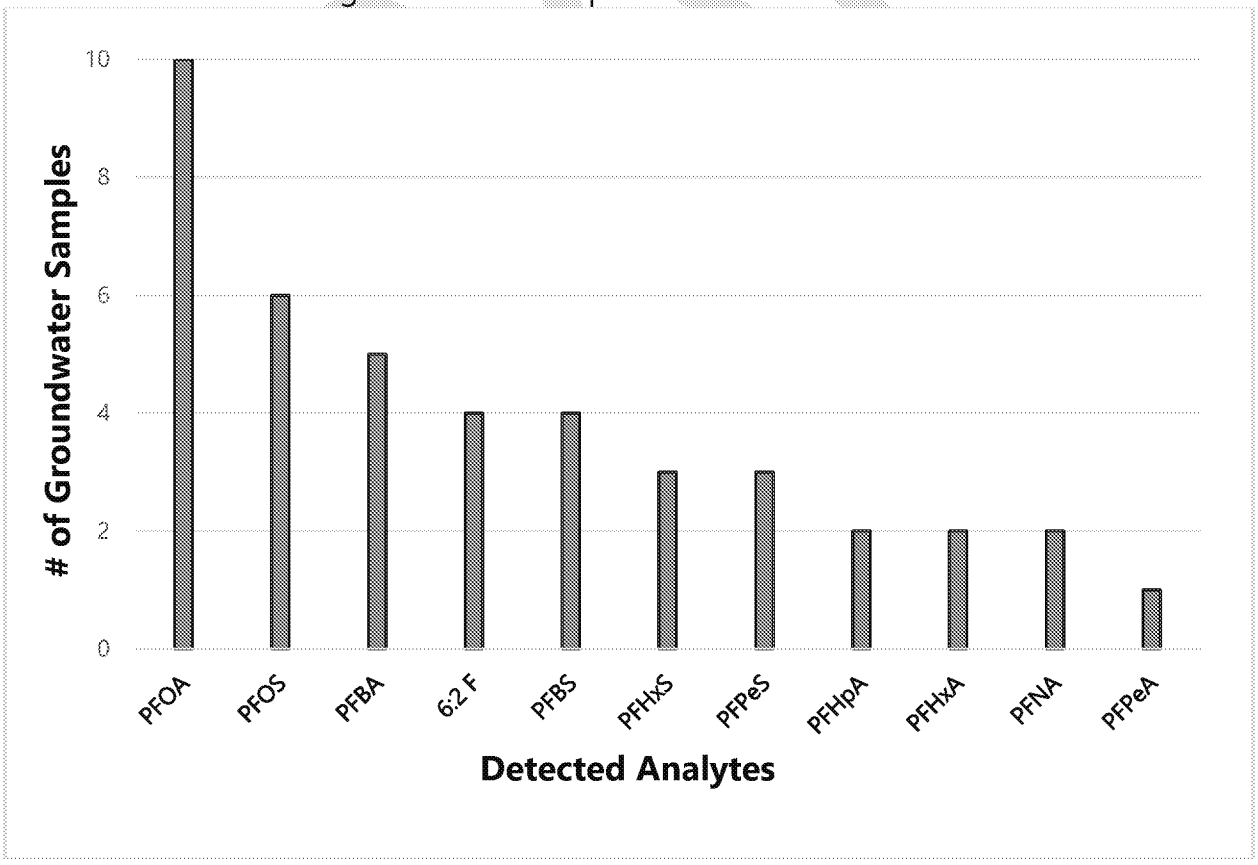


Table 7. Groundwater monitoring well samples with PFAS analytical detections

Site Identification			Landfill 3 MW 2	Landfill 4 MW 1	Landfill 5 MW 1	Landfill 5 MW 2	Landfill 7 MW 1	Landfill 10 MW 2	Landfill 12A MW 1	Landfill 14 MW 1	Landfill 16 MW 2	FTA 4	FTA 5	GW 1
Analyte	Health Advisory Limit	Unit	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results
6:2 fluorotelomersulfonate	Not Established	ppt	N.D.	N.D.	**3.5**	N.D.	**9.6 J**	N.D.	**1.0 J**	N.D.	N.D.	N.D.	**4.4 J**	N.D.
PFOS	70	ppt	N.D.	N.D.	**0.47 J**	N.D.	N.D.	**1.3 J**	**0.46 J**	**1.1 J**	N.D.	**9.6 J**	**60**	N.D.
PFOA		ppt	N.D.	**3.0 J**	**0.94 J**	**0.34 J**	**1.5 J**	**0.97 J**	**0.46 J**	**1.2 J**	**0.84 J**	**90**	**16**	N.D.
PFBS	Not Established	ppt	**6.4**	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	**2.1 J**	N.D.	**73**	**1.5 J**	N.D.
PFBA	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	**25**	N.D.	**5.4 J**	N.D.	**69**	**11 J**	**3.6 J**
PFHpA	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	**110**	**1.3 J**	N.D.
PFHxS	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	**5.2**	N.D.	**410**	**15**	N.D.
PFHxA	Not Established	ppt	**2.6 J**	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	**130**	N.D.	N.D.
PFNA	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	**3.1 J**	**51**	N.D.
PFPeS	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	**1.0 J**	N.D.	**77**	**1.4 J**	N.D.
PFPeA	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	**160**	N.D.	N.D.

Notes:
N.D. - Non Detect
J - Indicates an Estimated Value
Bold - Analytical Detection
[ ] - Analytical Exceedance

4.3 Drinking Water Treatment Plants

Each drinking water treatment plant had two samples collected: one sample from the source water and one sample from the treated water. A source water sample was defined as a sample taken before any treatment has occurred, and a treated water sample was defined as a sample taken after treatment has occurred and the water is ready for public distribution. A total of 14 primary samples were collected from seven drinking water treatment plants.

Five of the treatment plants, DW 1, DW 2, DW 3, DW 4, and DW 6, had low-level detections of PFOS, PFOA, PFBS, PFB, PFHpA, PFHxS, PFHxA, PFNA, and PFPeA in both the source and treated water samples. DW 6 had only low-level detections of PFBS and PFHxS in the treated sample. Overall, detections of PFOS were found in four samples and PFOA in 10 samples; however, none of these detections exceeded the EPA's HAL.

Chart 4 presents the number of samples with detected analytes. Analytical detections are in Table 8. Complete analytical laboratory results can be found in Appendix B.

Chart 4. The number of drinking water samples with PFAS detections

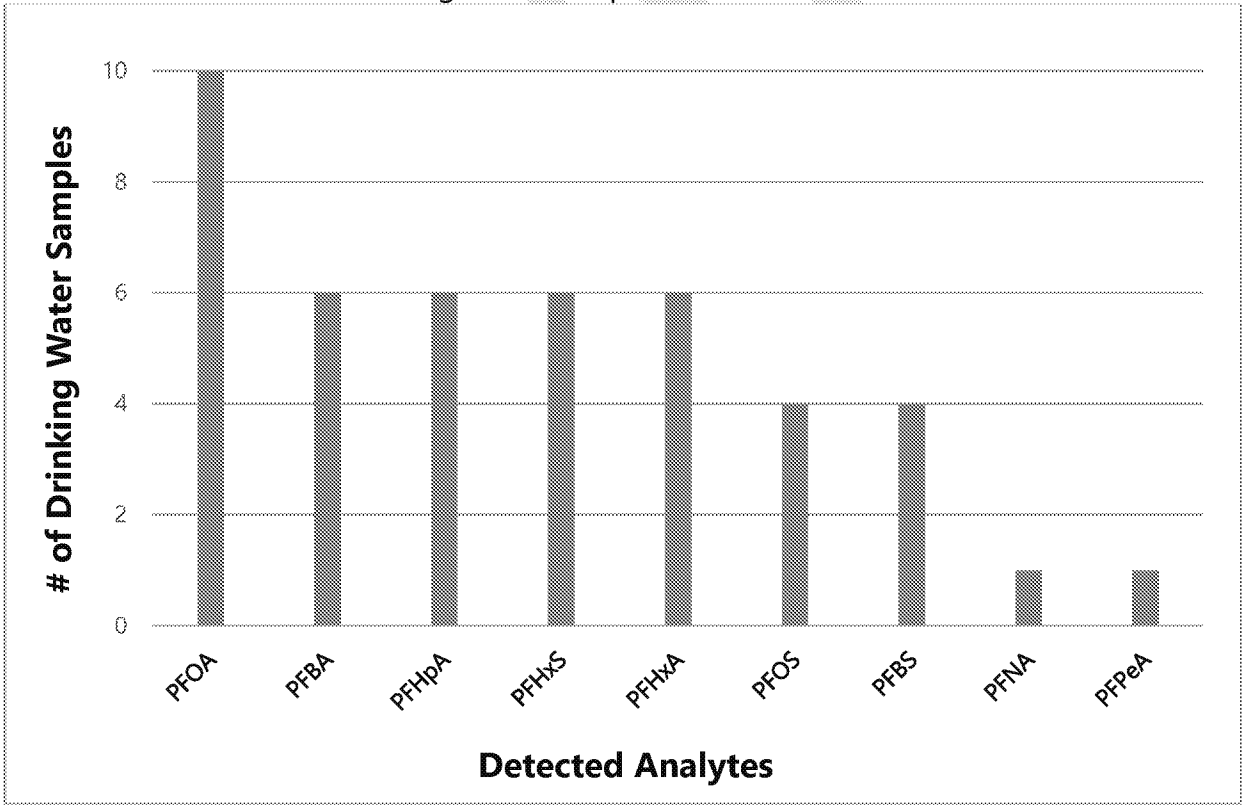


Table 8. Drinking water treatment plant samples with PFAS analytical detections

Site Identification			DW 1		DW 2		DW 3		DW 4		DW 6	DW 7	
DW Type			Source	Treated	Source	Treated	Source	Treated	Source	Treated	Treated	Source	Treated
Analyte	Health Advisory Levels	Unit	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results
PFOS	70	ppt	N.D.	N.D.	N.D.	N.D.	N.D.	**0.45 J**	N.D.	**0.37 J**	N.D.	**1.3 J**	**1.1 J**
PFOA		ppt	**0.61 J**	**0.45 J**	**0.79 J**	**0.89 J**	**0.78 J**	**0.85 J**	**0.82 J**	**0.80 J**	N.D.	**0.76 J**	**0.77 J**
PFBS	Not Established	ppt	N.D.	N.D.	**1.3 J**	**0.39 J**	N.D.	**0.43 J**	N.D.	N.D.	**0.40 J**	N.D.	N.D.
PFBA	Not Established	ppt	N.D.	**2.1 J**	N.D.	**7.6**	**4.9 J**	**4.7 J**	**7.4 J**	**7.4**	N.D.	N.D.	N.D.
PFHpA	Not Established	ppt	N.D.	N.D.	N.D.	**1.6**	**0.70 J**	**0.62 J**	**0.96 J**	**0.89 J**	N.D.	N.D.	**0.41 J**
PFHxS	Not Established	ppt	N.D.	**0.42 J**	**2.2 J**	**0.76 J**	N.D.	N.D.	N.D.	N.D.	**0.51 J**	**0.77 J**	**0.77 J**
PFHxA	Not Established	ppt	N.D.	N.D.	N.D.	**1.4 J**	**1.0 J**	**0.99 J**	**0.96 J**	**1.0 J**	N.D.	N.D.	**0.55 J**
PFNA	Not Established	ppt	N.D.	N.D.	N.D.	**0.47 J**	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PFPeA	Not Established	ppt	N.D.	N.D.	N.D.	**13**	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Notes:

N.D. - Non Detect

J - Indicates an Estimated Value

Bold - Analytical Detection

[ ] - Analytical Exceedance

4.4 Wastewater Treatment Plants

A total of 11 primary samples were collected from wastewater treatment plants across the state, and at least one PFAS analyte was detected in each of the samples. PFOS, PFOA, PFHpA, and PFHxA were found in all 11 samples and PFBS, PFBA, PFHxS, and PFNA were found in 10. PFOS and PFOA were detected in all the collected samples though not at levels that exceeded the EPA's HAL.

Chart 5 presents the number of drinking water treatment plant samples with PFAS detections. Analytical detections and exceedances are in Table 9. Complete analytical laboratory results can be found in Appendix B.

Chart 5. The number of wastewater treatment plant samples with PFAS detections

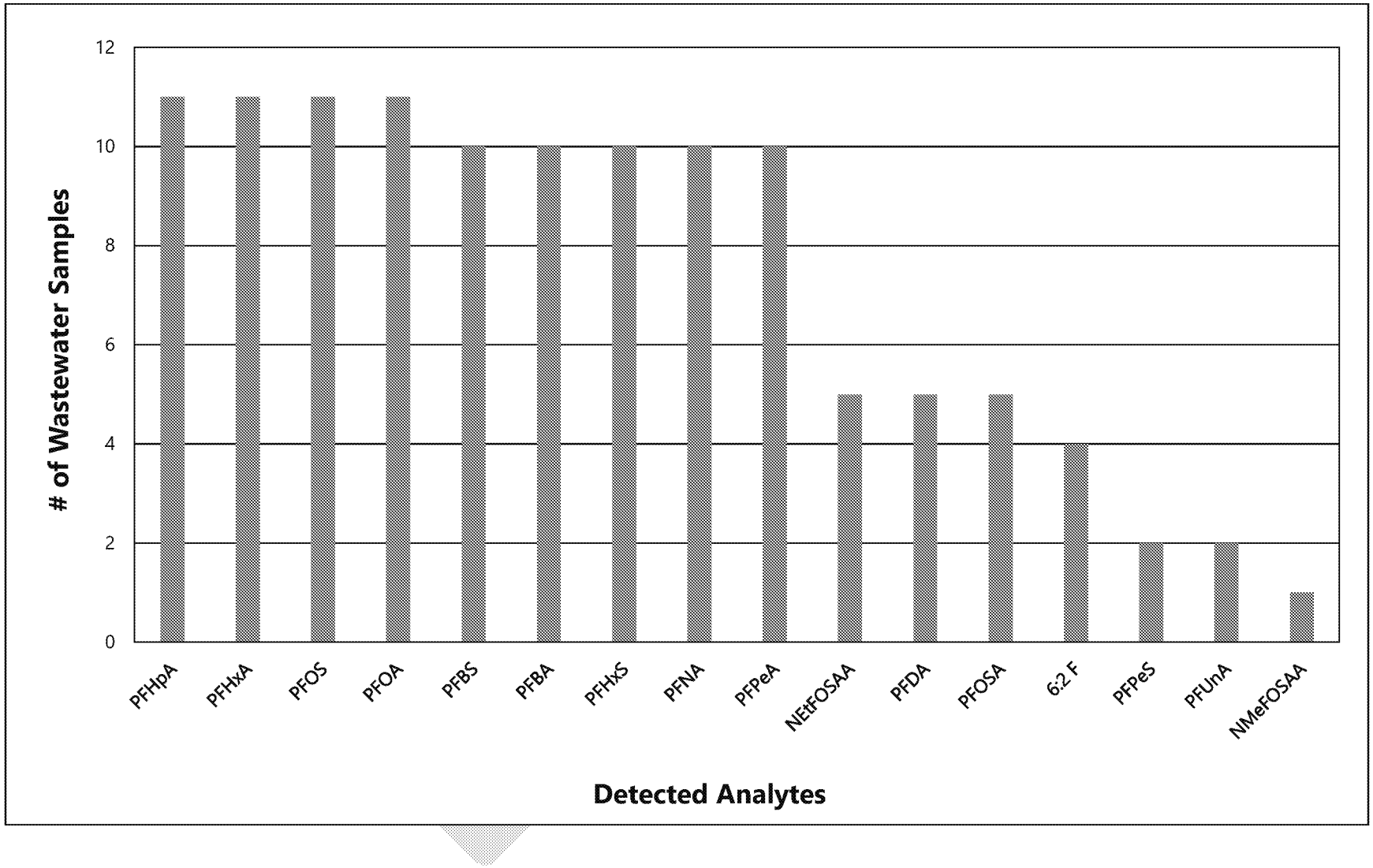


Table 9. Wastewater treatment plant analytical detections and exceedances

Site Identification:			WWTP 1	WWTP 2	WWTP 3	WWTP 4	WWTP 5	WWTP 6	WWTP 7	WWTP 8	WWTP 9	WWTP 10	WWTP 11
Analyte	Health Advisory Levels	Unit	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results
6:2 F	Not Established	ppt	**1.1 J**	N.D.	**1.5 J**	N.D.	N.D.	N.D.	**15**	N.D.	N.D.	N.D.	**2.5**
NEtFOSAA	Not Established	ppt	N.D.	**3.4 J**	**1.3 J**	N.D.	**2.0 J**	**3.2**	N.D.	N.D.	**1.4 J**	N.D.	N.D.
NMeFOSAA	Not Established	ppt	N.D.	N.D.	N.D.	N.D.	**3**	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PFOS	70	ppt	**2.5**	**23**	**12**	**29**	**5.1**	**15**	**7**	**3**	**6.6**	**2.0 J**	**3.6**
PFOA		ppt	**6.2**	**35**	**29**	**22**	**8.8**	**9.9**	**6.3**	**2.4**	**7.7**	**3**	**3.4**
PFBS	Not Established	ppt	**6.7**	**6.7**	**2.4**	**1.3 J**	N.D.	**3.3**	**3.1**	**1.8**	**1.4**	**1.7 J**	**3**
PFBA	Not Established	ppt	**9.5**	**28**	**22**	**13 J**	**4.3 J**	**18**	**10**	**4.0 J**	**9.7**	N.D.	**4.1 J**
PFDA	Not Established	ppt	N.D.	**4.1 J**	**2.7**	N.D.	**2.1**	**1.9 J**	**0.91 J**	N.D.	N.D.	N.D.	N.D.
PFHpA	Not Established	ppt	**5.4**	**9.3**	**14**	**9.9**	**2.9**	**6**	**3.3**	**0.81 J**	**3.3**	**1.1 J**	**1.4**
PFHxS	Not Established	ppt	**1.2 J**	**13**	**5.2**	**5.3**	**1.7 J**	**9.9**	**3.8**	**1.5 J**	**2.6**	N.D.	**3.1**
PFHxA	Not Established	ppt	**16**	**45**	**55**	**47**	**16**	**21**	**30**	**8.9**	**21**	**3.0 J**	**13**
PFNA	Not Established	ppt	**0.92 J**	**8.8**	**6.4**	**5.8**	**1.9 J**	**3**	**1.0 J**	**0.47 J**	**1.8 J**	N.D.	**0.83 J**
PFOSA	Not Established	ppt	N.D.	N.D.	**1.8 J**	N.D.	**0.82 J**	**0.80 J**	N.D.	N.D.	**0.87 J**	**1.5 J**	N.D.
PFPeS	Not Established	ppt	N.D.	N.D.	**0.59 J**	N.D.	N.D.	**0.87 J**	N.D.	N.D.	N.D.	N.D.	N.D.
PFPeA	Not Established	ppt	**29**	**14 J**	**23**	**21**	**6.5**	**34**	**17**	**7.1**	**8.5**	N.D.	**6**
PFUnA	Not Established	ppt	N.D.	N.D.	**0.41 J**	N.D.	**0.51 J**	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Notes:
N.D. - Non Detect
J - Indicates an Estimated Value
Bold - Analytical Detection
☐ - Analytical Exceedance

4.5 Miscellaneous Sample

One sample of RO-purified laboratory grade water was collected from the department's chemistry laboratory to determine if it could be used for future PFAS sampling events. Results indicate several low-level PFAS analytical detections, including PFOA. Analytical detections and exceedances are presented in Table 10. Complete analytical laboratory results can be found in Appendix B.

Table 10. Reverse osmosis purified laboratory grade water detections and exceedances

		Site Identification	RO-Purified DW
Analyte	Health Advisory Levels	Unit	Results
PFOA	70	ppt	**3.3**
PFBA	Not Established	ppt	**23**
PFHpA	Not Established	ppt	**100**
PFHxA	Not Established	ppt	**6.4**
PFNA	Not Established	ppt	**20**
PFPeA	Not Established	ppt	**670**

Notes:
N.D. - Non Detect
J - Indicates an Estimated Value
Bold - Analytical Detection
[ ] - Analytical Exceedance

4.6 Equipment Blank Samples

Three equipment blank samples were taken — two from disposable bailers and one from peristaltic pump tubing. As the equipment being used is disposable and not being decontaminated, one blank from each of the two types of bailers being used and the peristaltic pump tubing was sufficient. Laboratory results from the samples indicate that there were no detections of PFAS analytes. Complete analytical laboratory results can be found in Appendix B.

4.7 Field Blank Samples

Eight field blank samples were taken, slightly higher than the 10% rate as written in the Quality Assurance Project Plan (NDDoH, 2018A). Laboratory results from the field blank samples indicate that there were no detections of PFAS analytes. Complete analytical laboratory results can be found in Appendix B.

5.0 Work Plan Deviations

Deviations from the work plan did occur and are as follows.

A leachate sample from Landfill 16 was not collected due to the on-site leachate pond having been emptied the previous day in anticipation of construction. However, field personnel were able to collect groundwater samples from on-site monitoring wells (Landfill 16 MW 1 and Landfill 16 MW 2).

Leachate samples were not collected from landfills associated with groundwater samples Landfill 14 MW 1, Landfill 15 MW 1, and Landfill 15 MW 2 as these landfills are capped and have been inactive for at least 10 years.

Groundwater samples from monitoring wells at Landfills 1, 2, and 11 were not collected as the wells contain dedicated bladder pumps and Teflon lined tubing and field personnel were unable to secure permission from these landfills to remove the pumps and tubing to take groundwater samples.

Groundwater samples could not be collected from monitoring wells at Landfill 9 as the wells were dry at the time of sampling.

Groundwater samples from Landfill 13 were not collected. Landfill 13 is a newer landfill that was opened after the change in EPA's rules for landfills were enacted, and the work group decided that taking a groundwater sample was not necessary.

Groundwater sample FTA 1 was taken approximately 0.25 miles from the actual fire training area due to field personnel being unable to secure permission from the landowners to collect a sample from the on-site monitoring wells.

6.0 Conclusions

The goal of this survey was to determine the presence or absence of PFAS in the state of North Dakota. Based on the study results, PFAS was found where expected — landfill leachate ponds, waste water treatment plants, and fire training areas.

The landfill leachate samples were found to contain more analytical detections and higher levels of PFAS than samples taken from non-landfill sites (Table 6). This was expected as the landfills sampled had been specifically selected due to their acceptance of waste from a variety of municipal and industrial sources. Of the 18 leachate samples collected, 15 were found to exceed the EPA's PFOS + PFOA HAL. Seventeen groundwater samples were associated with landfills. Of those samples, 12 were taken in conjunction with leachate samples, and five were taken from landfills that had been closed for several years or more and leachate was no longer available to sample.

Analytical results from the groundwater samples indicate that either the landfill liners are intact, or if they are leaking, the contamination is not reaching or has not yet reached the underlying groundwater (Table 7).

Wastewater treatment plants contained the second greatest number of analytical detections, although at levels are far lower than those from the leachate samples (Table 9). Many landfills discharge their leachate to wastewater treatment plants, so analytical detections were expected.

Samples from monitoring wells FTA 4 and FTA 5 were collected from the same site around a fire training area. Both wells had multiple analytical detections as well as exceeded the EPA's PFOS + PFOA HAL (Table 7). These samples were taken from a private fire training area that is still active and near a wastewater pond.

The chemistry laboratory RO-purified laboratory grade water is not appropriate to be used for PFAS analysis due to the presence of low levels of PFAS.

While not conclusive with only one sample, oilfield-related brine water does not appear to be a significant source of PFAS.

7.0 Discussion and Recommendations

The PFAS survey indicates that contamination exists at landfills and wastewater treatment plants. PFAS contamination tends to be a larger issue in states that have a more industrialized and manufacturing economy than what is found in North Dakota. The only places that were not sampled by department personnel were the military bases found in Bismarck, Minot, Fargo, and Grand Forks. Discussions with environmental personnel from these bases indicated that the military is performing PFAS studies and once the reports are finalized, the data will be shared with the department. Once the reports have been received and reviewed, their conclusions will be incorporated into any future decisions and actions.

Several data gaps have been identified. Very few permanent or long-term fire training areas have been identified and the ones located either had no monitoring wells available at the site or the wells were deeper than 100 feet. For future studies, key people within the firefighting community and the North Dakota Firefighter's Association should be identified and contacted about potential training area locations and the types of fire retardant that have been used used. If funding can be secured, a drill rig or

Geoprobe could be used to drill temporary monitoring wells, or soil sampling can be considered as an alternative to collecting water samples.

Monitoring wells located at Landfills 1, 2, and 11 could not be sampled due to department personnel being unable to secure permission from landfill management. These landfills should perform a one-time PFAS sample event as a part of their regular water quality monitoring programs to determine if any contamination from their landfills or leachate ponds has reached groundwater.

Further studies should include wastewater treatment plants that accept landfill leachate discharge, and those plants should be sampled, if they have not yet. If any plants treat their sludge so that it's transformed into biosolid to be applied to farmland, it should be sampled to determine if there is any PFAS contamination present.

8.0 References

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Appendix A

Analyte List

eurofins | Lancaster Laboratories Environmental

PFAS by EPA 537 Rev 1.1, modified (Isotopic Dilution)

Compound	CAS Number	LOQ	MDL	Units
10:2-fluorotelomersulfonate	120226-60-0	9	3	ng/l
4:2 fluorotelomersulfonate	757124-72-4	3	1	ng/l
6:2 fluorotelomersulfonate	27619-97-2	9	3	ng/l
8:2 fluorotelomersulfonate	39108-34-4	6	2	ng/l
NEtFOSAA	2991-50-6	3	1	ng/l
NEtPFOSA	4151-50-2	9	3	ng/l
NEtPFOSAE	1691-99-2	3	1	ng/l
NMeFOSAA	2355-31-9	3	1	ng/l
NMePFOSA	31506-32-8	9	3	ng/l
NMePFOSAE	24448-09-7	3	1	ng/l
Perfluoro-octanesulfonate	1763-23-1	2	0.4	ng/l
Perfluorobutanesulfonate	375-73-5	1	0.3	ng/l
Perfluorobutanoic acid	375-22-4	6	2	ng/l
Perfluorodecanesulfonate	335-77-3	2	0.6	ng/l
Perfluorodecanoic acid	335-76-2	2	1	ng/l
Perfluorododecanesulfonate	79780-39-5	1	0.3	ng/l
Perfluorododecanoic acid	307-55-1	1	0.3	ng/l
Perfluoroheptanesulfonate	375-92-8	2	0.4	ng/l
Perfluoroheptanoic acid	375-85-9	1	0.3	ng/l
Perfluorohexadecanoic acid	67905-19-5	1	0.3	ng/l
Perfluorohexanesulfonate	355-46-4	2	0.4	ng/l
Perfluorohexanoic acid	307-24-4	2	0.4	ng/l
Perfluorononanesulfonate	474511-07-4	2	0.6	ng/l
Perfluorononanoic acid	375-95-1	2	0.4	ng/l
Perfluorooctadecanoic acid	16517-11-6	1	0.3	ng/l
Perfluorooctanesulfonamide	754-91-6	3	1	ng/l
Perfluorooctanoic acid	335-67-1	1	0.3	ng/l
Perfluoropentanesulfonate	2706-91-4	2	0.4	ng/l
Perfluoropentanoic acid	2706-90-3	6	2	ng/l
Perfluorotetradecanoic acid	376-06-7	1	0.3	ng/l
Perfluorotridecanoic acid	72629-94-8	1	0.3	ng/l
Perfluoroundecanoic acid	2058-94-8	2	0.4	ng/l

Reporting limits are evaluated periodically and are subject to change.

Appendix B

Laboratory Results